Response of Lowland Rice to Inorganic and Organic Amendments on Soils Disturbed by Grading in Eastern Arkansas

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ABSTRACT

In eastern Arkansas, yields of rice growing on subsoil materials exposed as a result of land grading are low and often cannot be improved through the application of inorganic N-P-K fertilizers. In this two-year field study, experimental plots located on eight recently graded fields were amended with inorganic (P, K, S, Zn and gypsum) and organic (uncomposted broiler litter, composted broiler litter and rice scalping) materials, alone and in various combinations, and planted to rice. Composted and uncomposted broiler litter, applied at rates ranging from 280 to 4480 kg/ha, were most effective in increasing rice yields relative to the fertilized but otherwise unamended control. Rice scalping at rates up to 6720 kg/ha had no effect on rice yields. With the exception of gypsum application to sodic soil, applications of a single inorganic amendment were ineffectual compared with applications of litter, although significant rice yield increases were occasionally obtained when two or more inorganic amendments were applied together.

INTRODUCTION

Land grading is popular among rice farmers because it simplifies levee construction and facilitates efficient use of water (Nir, 1983). However, the subsoil that is exposed during the leveling operation is frequently infertile and difficult to manage (Miller, 1990). As a result, yields of rice and soybean growing on deeply cut areas of leveled fields are often quite low. In many cases soil tests are unable to identify the element or elements that are limiting yields.

This study reports the yield response of rice grown on graded soils to additions of inorganic (zinc, potassium, phosphorus, sulfur or gypsum) or organic (composted and uncomposted chicken litter or rice scalping) amendments, alone and in various combinations. Zinc was chosen as a treatment because of the well-known tendency for rice to suffer from zinc deficiency in eastern Arkansas (Wells et al., 1973) and because zinc deficiency in graded soils has been documented (Grunes et al., 1961). Because graded soils are typically low in organic matter (Olson, 1977; Jessop et al., 1985), and because both phosphorus (Broadbent, 1986) and sulfur (Stevenson, 1986) deficiencies are frequently associated with low organic matter contents, P and S treatments were included. Gypsum was used as a treatment on those soils believed to be sodic because it has been shown to be effective in the reclamation of such soils (Loveday, 1984). Organic waste treatments were included because additions of organic residues have been shown to be effective in restoring productivity to both disturbed (Carlson et al., 1961; Mbagwu, 1985) and salt-affected (Lipman and Gericke, 1919; Gupta and Abrol, 1990) soils.

MATERIALS AND METHODS

The fields in which the tests were conducted were located in Jackson County, Arkansas. Site designations and selected site characteristics are listed in Table 1. Chicken litter compost (CLC), chicken litter (CL), composted rice scalping (CRS), gypsum (GYP) and phosphorus were applied preplant at all locations and were incorporated to a depth of ap-

Table 1. Experimental site characteristics.

Site	Graded	Soil Mapping Unit	Comments
Connor #1 (C1)	1985	Calhoun silt loam	High Ca, low Na
Connor #2 (C2)	1987	Dexter Silt loam	Low P, pH 7
Connor #3 (C3)	1987	Foley-Calhoun complex	Moderate sodicity
Lewis (L)	1988	Foley-Calhoun complex	Severe sodicity
Huey A (HA)	1989	Bosket sandy loam	Loamy sand, pH 6
Huey B (HE)	1989	Oundee silt loam	Silty clay loam, pH 5.5
Lewellyn (LEW)	1989	Dundee/Bosket	Highly variable

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proximately 4 in. The zinc was applied after seedling emergence as a chelate at all sites. Total N, P and K contents (%, dry weight basis) of the organic amendments were 4.24, 1.06 and 1.30 for the CL and 3.30, 2.09 and 2.40 for the CLC, respectively. The N content of the CRS was 0.64%. Application rates for the various amendments and treatment combinations are shown in Tables 2 and 3 for the 1989 tests and in Table 4 for the 1990 tests. At each site, a completely randomized block design with four replications was used, giving a total of 64 plots per site at all sites except at Lewellyn (LEW), where only 10 treatments (40 plots) were installed due to space limitations. Plot size was 1.8 x 4.6 m.

All plots were in farmers' fields and were fertilized with N by the farmer according to the N requirements of the cultivar being grown. In general, N fertilization consisted of a preflood topdress application of urea with one or two subsequent aerial applications of urea during the growing season (134 - 157 kg total N/ha). In 1989 'Tebonnet' was planted at Huey A (HA) and Huey B (HB) on 20 April and at Lewis (L) on 26 April, while 'Newbonnet' was planted at Connor 1 (C1) on 20 April and at Connor 2 (C2) on 26 April. In 1990, Tebonnet was planted at LEW on 10 May while a mixture of two genotypes was planted at Connor 3 (C3) on 15 May (hybrid seed was being produced on this farm). A 3.7 x 0.8 m area of each plot was harvested on 15 September (HA and HB), 18 September (L and C1) or 20 September (C2) 1989 or on 22 September 1990 (LEW and C3). Grain yields, corrected for moisture, are shown in Tables 2 through 4.

RESULTS AND DISCUSSION

At the HA site mean yields ranged from 1093 (P) to 5537 (CLC +Zn+P) kg/ha. There was a great deal of variability among replicates at this site, possibly due to herbicide runoff from an adjacent road embankment. As a result, the yields of only two treatments, CLC+S and CLC+Zn+P, were significantly greater than that of the control. At the HB site mean yields ranged from 2812 (S) to 6903 (CLC+Zn+S+P) kg/ha. The yields of nine treatments significantly exceeded that of the control; of these, eight were treatments involving CLC. At the L site mean yields ranged from 2014 (control) to 6515 (CLC+GYP+Zn) kg/ha. The yields of 12 treatments (all except Zn and P) were significantly greater than that of the control. The seven highest-yielding

Table 2. Rice response to chicken litter compost, Zn, S and P when grown on a precision-leveled Bosket fine sandy loam soil., J.D. Huey farm, Jackson Co., Arkansas, 1989.

Treatment				Grain Yield	
C.L.C.[1]	Zn[2]	S[3]	P[4]	Site A[5]	Site B[6]
kg/ha				kg/ha	
0	0	0	0	2641	3614
0	1.12	0	0	4114	3811
0	0	22.4	0	1901	2813
0	0	0	22.4	1093	3548
2240	0	0	0	3596	5852
0	1.12	22.4	0	3151	4453
0	1.12	0	22.4	3695	5230
2240	1.12	0	0	3833	6433
0	0	22.4	22.4	3033	5274
2240	0	22.4	0	5269	6718
2240	0	0	22.4	3153	6255
0	1.12	22.4	22.4	1838	5716
2240	0	22.4	22.4	2843	6552
2240	1.12	22.4	0	4468	6381
2240	1.12	0	22.4	5537	6743
2240	1.12	22.4	22.4	2682	6902
$LSD_{.05}$				2151	1816

[1]C.L.C. = chicken liner compost
[2]Zn as Zn EDTA.
[3]S as $CaSO_4$.
[4]P as TSP.
[5]Sand base.
[6]Clay base.

Table 3. Response of rice to chicken litter compost, Zn, P and gypsum when grown on graded soils suspected of having a nitric B horizon. Jackson Co., Arkansas, 1989.

Treatment				Grain Meld		
Zn[1]	Gypsum[2]	CLC[3]	P[4]	Lewis[5]	C1[6]	C2[7]
kg/ha				kg/ha		
0	0	0	0	2014	5320	4463
1.12	0	0	0	2614	5414	4638
0	4480	0	0	4218	4997	4171
0	0	2240	0	5768	6475	7145
0	0	0	22.4	2629	6230	6092
1.12	4480	0	0	3308	4436	5622
1.12	0	2240	0	6288	7170	7705
1.12	0	0	22.4	3720	6622	7268
0	4480	2240	0	5676	6359	7595
0	4480	0	22.4	4784	6092	7194
0	0	2240	22.4	5077	6792	8243
1.12	4480	2240	0	6515	5643	8110
0	4480	2240	22.4	6431	5977	7903
1.12	4480	0	22.4	3993	5716	7262
1.12	0	2240	22.4	6014	6870	7116
1.12	4480	2240	22.4	5833	6690	8034
$LSD_{.05}$				1313	994	1209

[1]Zn as Zn EDTA
[2]Gypsum as $CaSO_4$.
[3]CLC = chicken litter compost.
[4]P as TSP.
[5]Tommy Lewis' farm.
[6]Connor - Holden - Grubbs.
[7]Connor - Holden - Ark. Rt. 18.

Table 4. Rice response to chicken litter, chicken litter compost, composted rice scalping and inorganic fertilizers on recently graded soils, Jackson County, Arkansas, 1990.

Treatment				Grain Yield	
CL[1]	CLC[2]	CRS[3]	P,K,Zn,S[4]	C3	LEW
kg/ha					
0	0	0	0,0,0,0	2531	4791
0	280	0	0,0,0,0	4240	NT[5]
0	560	0	0,0,0,0	3755	NT
0	1120	0	0,0,0,0	3862	4445
0	2240	0	0,0,0,0	4409	6189
0	4480	0	0,0,0,0	4115	6381
280	0	0	0,0,0,0	3884	NT
560	0	0	0,0,0,0	3727	NT
1120	0	0	0,0,0,0	4450	5887
2240	0	0	0,0,0,0	4426	6713
4480	0	0	0,0,0,0	4719	5770
0	0	2240	0,0,0,0	3349	5025
0	0	4480	0,0,0,0	NT	4705
0	0	6720	0,0,0,0	3082	4879
0	0	0	0,67,0,0	2345	NT
0	0	0	22.4,67,1.12,22.4	4015	NT
$LSD_{.05}$				993	1053

[1]CL = chicken litter.
[2]CLC = chicken litter compost.
[3]CRS = composted rice scalping.
[4]P as TSP, K as KCl, Zn as Zn EDTA, and S as elemental S.
[5]Treatment not performed at this location.

treatments, which did not differ significantly among themselves, were treatments involving CLC. The yield of the gypsum-only treatment was significantly greater than the yields of the zinc only, phosphorus only and control treatments. It is also interesting to note that the yield of the GYP+P treatment was not significantly different from the GYP+P +CLC+Zn treatment.

At the C1 site, mean yields ranged from 4435 (GYP+Zn) to 7170 (CLC+Zn) kg/ha Six of the seven treatments with yields significantly greater than the control received CLC; the one that did not was the Zn+P treatment. The yields of two treatments involving CLC (CLC+Zn+GYP and CLC+P+GYP) were no greater than that of the control. At the C2 site mean yields ranged from 4171 (GYP) to 8243 (CLC+P) kg/ha. The only treatments whose yields were not significantly greater than that of the control were Zn, GYP and GYP+Zn. The top six yielding treatments all involved CLC, but overall there were no significant differences in yields among the top eleven yielding treatments. A significant response to P applied alone was observed at the C2 site. At C1, response to this treatment was also significant but at a lower probability level (.10). Beyrouty et al. (1991) have reported significant rice yield responses to P fertiliztion on ungraded but otherwise similar soils.

The 1990 yield data presented in Table 3 indicate that both CLC and CL increased rice yields relative to the check plots, but one does not appear to be more effective than the other. By contrast, the CRS did not improve yields. From this it may be inferred that rice will not respond to all organic amendments in the same manner, and that litter, either fresh or composted, is likely to be superior to other organic amendments. At the C3 site, fertilization with K only was not effective, but fertilization with a mixture of P, K, Zn and S was as effective as any of the organic amendments.

There were no statistically Significant differences in yields among the CL and CLC treatments at the C3 site, regardless of application rate (Table 3). All CL and CLC treatments, however, were significantly greater than the checks. This indicates that at this particular site application of 280 kg/ha of either CL or CLC was just as effective in increasing yields as was application of 4480 kg/ha. However, grain yields at this site were limited by the use of two non-adapted rice lines to produce hybrid rice seed. Thus, the response to higher rates of CL or CLC may have been masked. Different results were obtained at LEW, where application of 1120 kg/ha of CLC did not significantly increase yields while 2240 and 4480 kg/ha did. On the other hand, application of 1120 or 2240 kg/ha of CL significantly increased yields while 4480 kg/ha did not. Thus, the optimum rate of application may be quite low in some cases, and the optimum rates of CL and CLC may not always be the same.

SUMMARY AND CONCLUSIONS

At all of the test sites there was a clear and consistent positive response to the CLC. In addition to producing greater grain yields, rice grown on CLC- or CL-amended plots was taller and matured earlier than rice grown on other plots. This was particularly noticeable at the L and LEW sites, where the surface soil was sodic. In addition, there appeared to be a positive response to gypsum at the sodic L site. Visual observations made throughout the growing season indicated that this gypsum response occurred primarily during the last half of the season. The lack of a response to gypsum at the C1 and C2 sites may have been due to the fact that the gypsum had insufficient time to leach into the profile during the course of the experiment. The fact that application of zinc alone did not significantly improve yields at any of the sites suggests that zinc fertilization by itself may be of limited value in restoring productivity to graded soils.

Fresh and composted chicken litter appear to be of equal effectiveness in improving rice yields on graded soils, but CRS did not improve yields. This indicates that organic amendments are not all equivalent in their ability to restore productivity to graded soils. The optimum application rate of CL and CLC appears to vary with site conditions, making generalizations difficult. Because of the relatively low N contents of the CL and CLC, and because mineralization of organic N is a slow process, it is unlikely that response of rice to CL or CLC is due to increased N availability.

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